Introduction

to

Global Positioning Systems (GPS)

Prepared for USDA

Module Goals

- GPS terminology
- GPS operation
- Differential correction
- Limitations of GPS
- Uses for GPS

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What is GPS?

GPS is a positioning system based on a network of satellites that continuously transmit coded information. The information transmitted from the satellites can be interpreted by receivers to precisely identify locations on earth by measuring distance from the satellites.

- GPS is funded by and controlled by the U. S. Department of Defense (DOD). The system is called NAVSTAR, which stands for "**Nav**igational **S**atellite **T**iming **a**nd **R**anging"
- GPS provides specially coded radio signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.
- The signals are available world wide and the system is designed to function in all weather conditions

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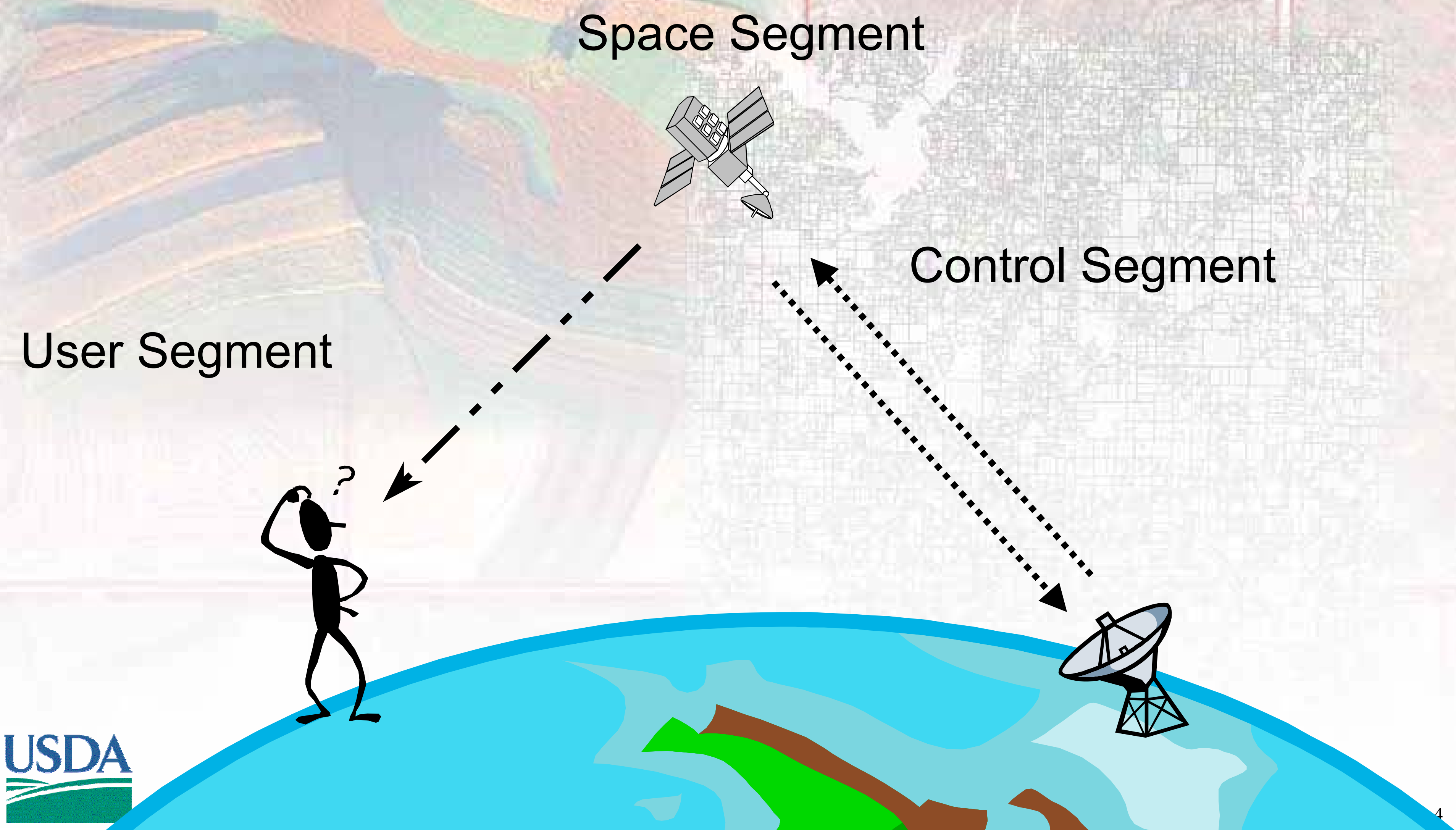
Three Components to GPS



GPS Constellation

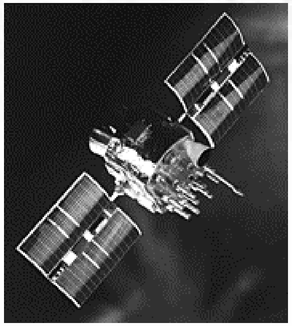
- The nominal GPS Operational Constellation consists of 24 satellites. Each satellite orbits the earth in about 12 hours.
- The satellite orbits repeat almost the same ground track once each day
- The GPS signal has information about the precise position of the satellite as well as precise time

GPS Satellite Signals

- Transmitted on the L1 radio frequency
- Almanac data
- Ephemeris data
- The precise time (Pseudo-Random Code)

GPS Control Segment

- DOD maintains five control stations around the world that monitor the satellites and update their orbital information
- Monitor stations track the position of the satellites and message that they are broadcasting
- Once each day, the master control station in Colorado sends data back to the satellites to make their signal more correct
- Corrected information is received by the GPS unit carried by military and civilian users all over the world

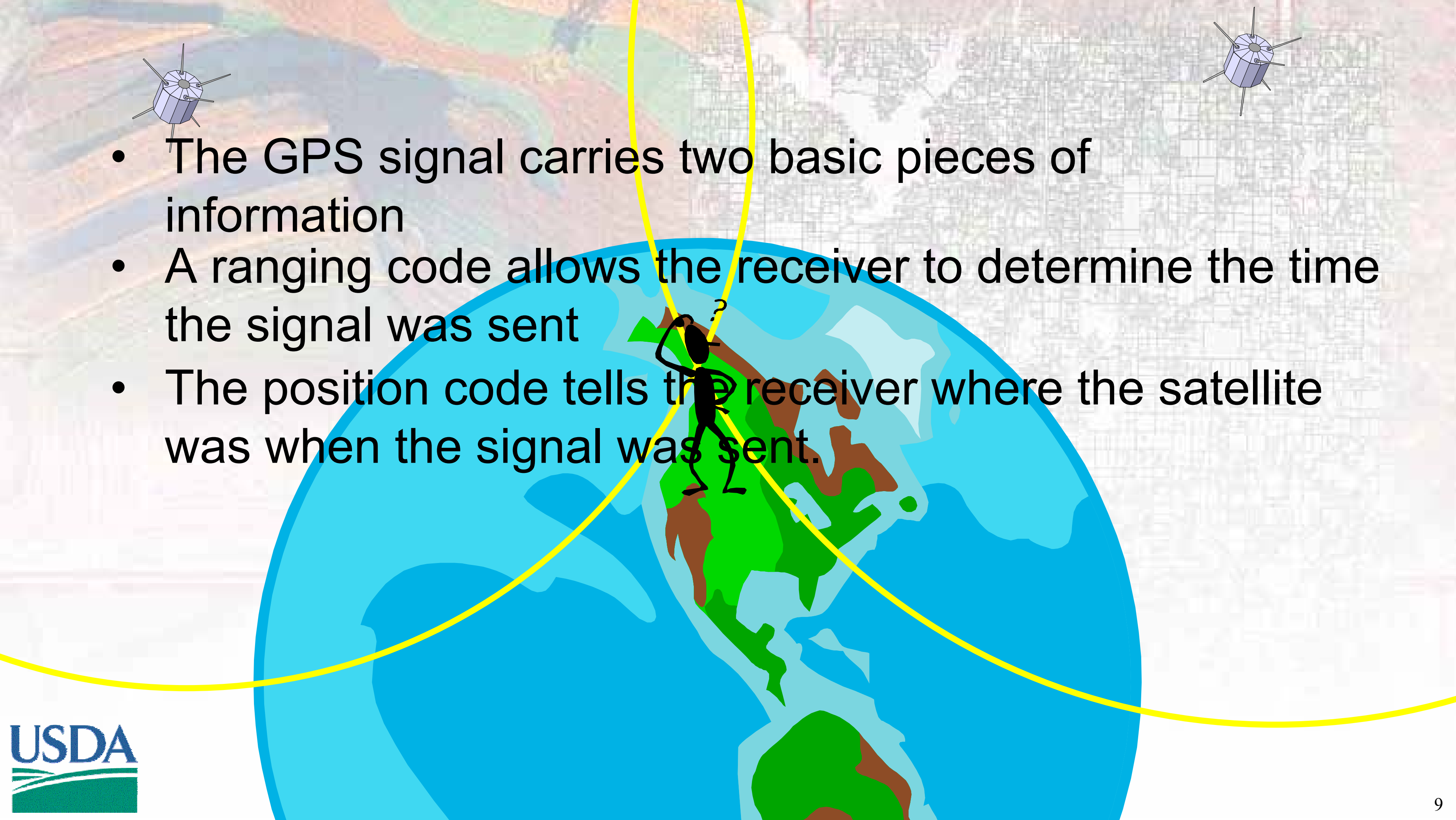


Satellite Ranging

- The GPS receivers figure out how far they are from the satellite by calculating the difference between when the signal was sent from the satellite and when it arrived at the receiver
- Distance = (Travel Time) * (Speed of Light)
- This distance is also known as the range

Positioning Using the GPS Signal

- The GPS signal carries two basic pieces of information
- A ranging code allows the receiver to determine the time the signal was sent
- The position code tells the receiver where the satellite was when the signal was sent.



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GPS Accuracy

GPS receivers are subject to several sources of error that decrease the accuracy of their readings. These include:

- Number and geometry of satellites visible - The more satellites the receiver can “see” the better. Trees, buildings, and terrain can block the signal, decreasing accuracy
- Signal multi-path - Occurs when the GPS signal is reflected off of objects such as tall buildings before it reaches the receiver
- Orbital and Satellite Clock errors - Inaccuracies of the satellites reported position and time
- Ionosphere and troposphere delays - The satellite signal can be slowed or refracted as it passes through the atmosphere
- Receiver clock errors - The clock built in to the receiver can have slight timing errors

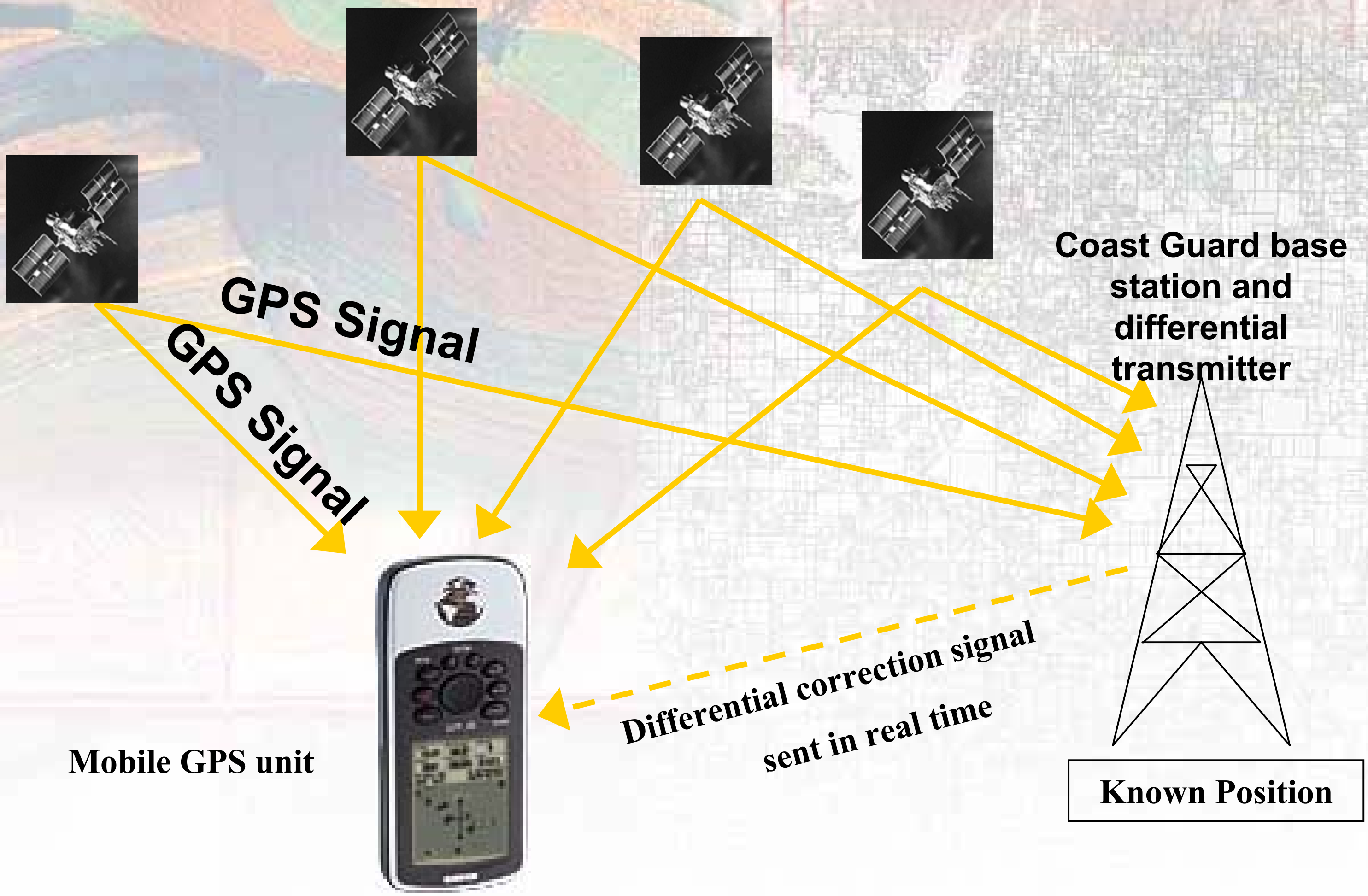
DGPS

Differential Global Positioning Systems

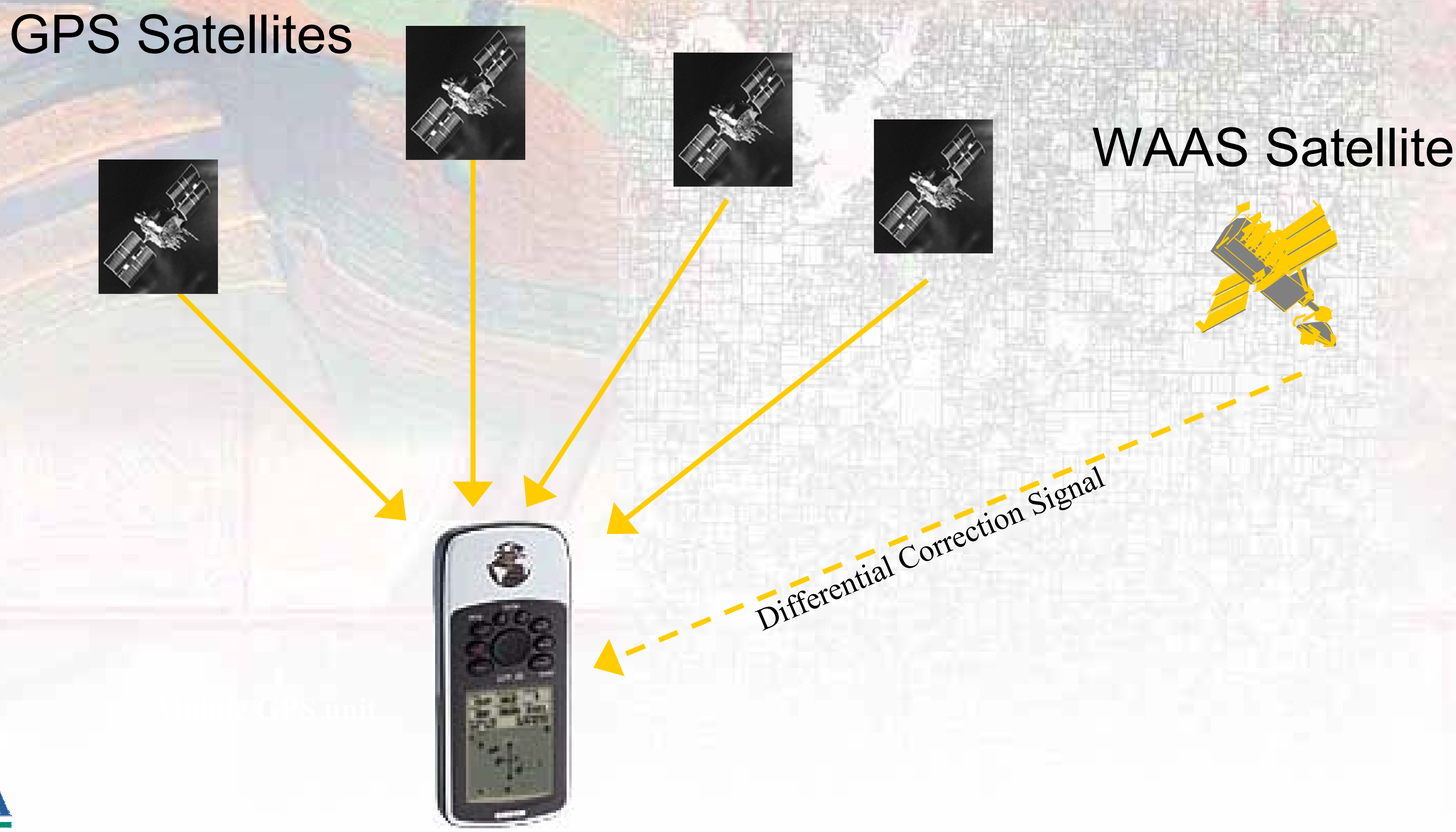
- DGPS improves the accuracy and integrity of standard GPS
- DGPS works by placing a GPS receiver at a known location, this is called a reference station
- The reference station knows its exact location, and therefore can calculate the difference between the GPS derived positions and the true position.
- These "differential corrections" are used to correct the positions obtained by roving GPS units either in real time or through post-processing
- Typical DGPS accuracy is between 1-5 meters, depending on the distance between the roving receiver and the reference station.
- Differential corrections are useful several hundred miles from the reference station

NDGPS

Nationwide Differential Global Positioning System

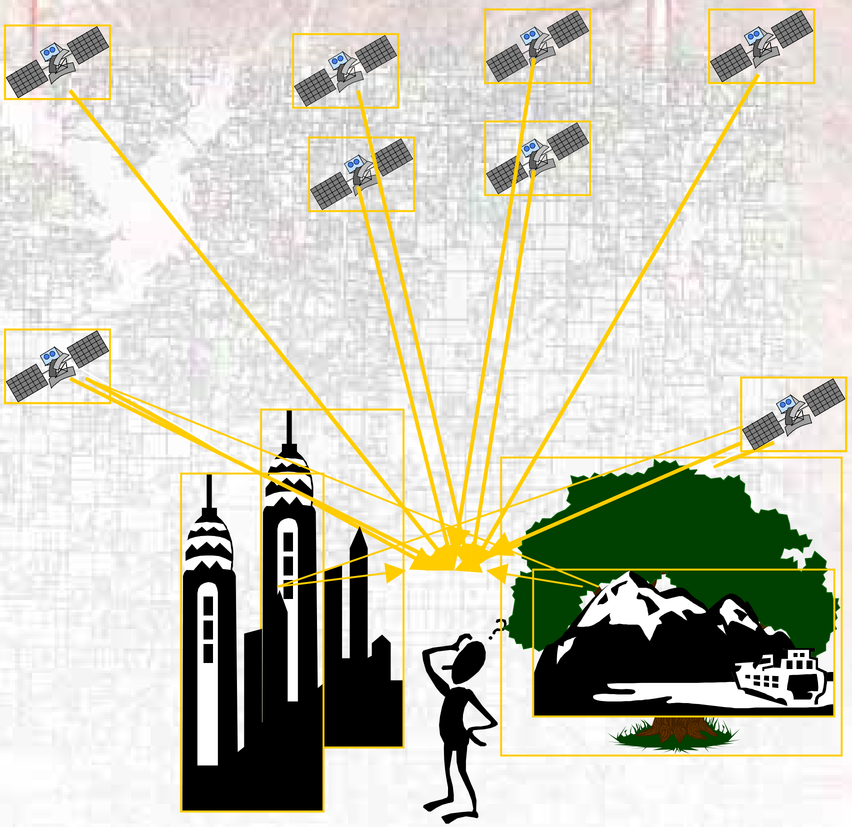


Wide Area Augmentation System (WAAS)



GPS Error not Addressed by DGPS

- Poor Satellite Geometry
- Poor Satellite Visibility
- Multipath Interference



Expected Accuracy varies by type of GPS unit

- Standard GPS - 15 m horizontal, 35m vertical
- NDGPS - 5 m horizontal
- WAAS - 7m total error, 3 m horizontal in tests
- Carrier Phase GPS - 10cm to 1meter
- Survey Grade - sub-centimeter

Comparison of GPS and Orthophoto Data

Orthophotos of the scale that are used in the service centers are required to have an accuracy of ± 33 feet, but are generally within ± 10 feet.

This is often not as good as the GPS accuracy.

Bottom Line

- Keep an eye on your estimated accuracy and make sure that the data you are gathering meets program accuracy standards.
- Understand that sometimes GPS will work better than other times.
- Be prepared to use other tools if GPS is not appropriate.

Uses for GPS

- Determine 3-Dimensional Positions
- Measure Lengths/Distances
- Measure Areas
- Navigation
- Precise Timing

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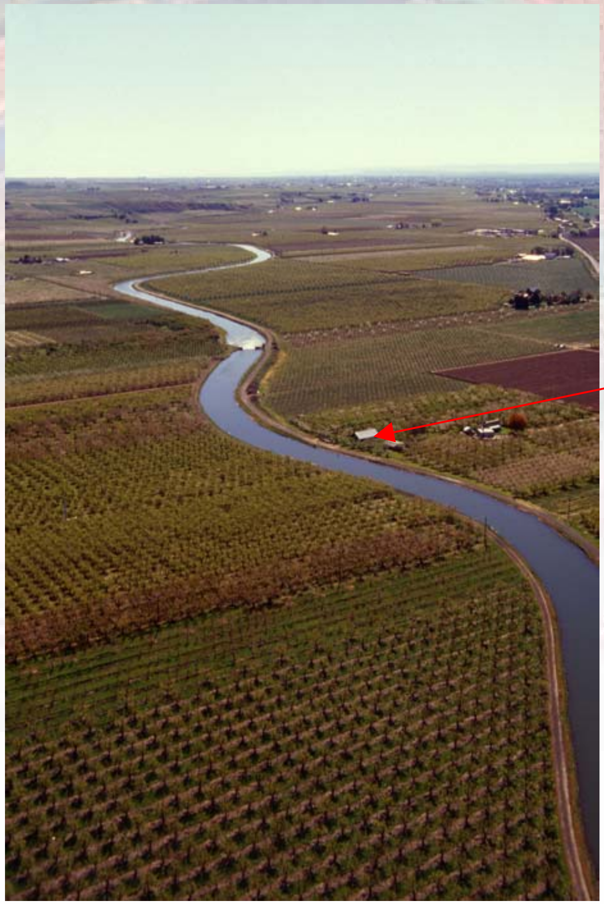
The key function of GPS is to locate your position on the Earth

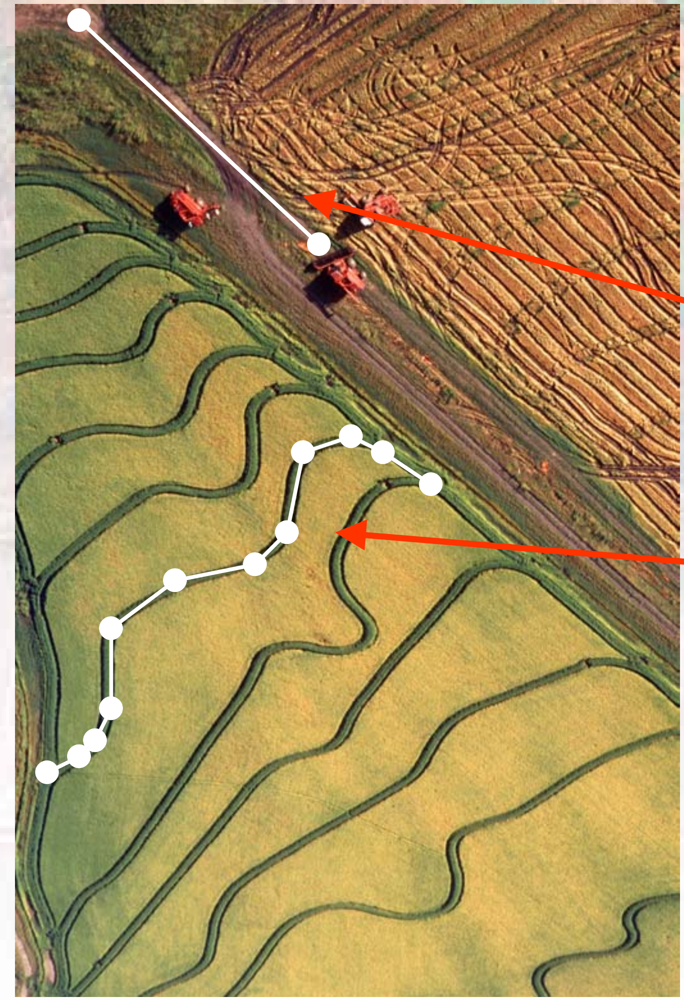


Barn Location

Latitude 39.5673 N

Longitude 115.345 W

GPS can be used to measure distances



Point to Point Distance = 200 ft

Length of Berm = 350 ft

GPS can be used to measure areas

Rectangular field measured using corner points

A circular field would best be measured using a track

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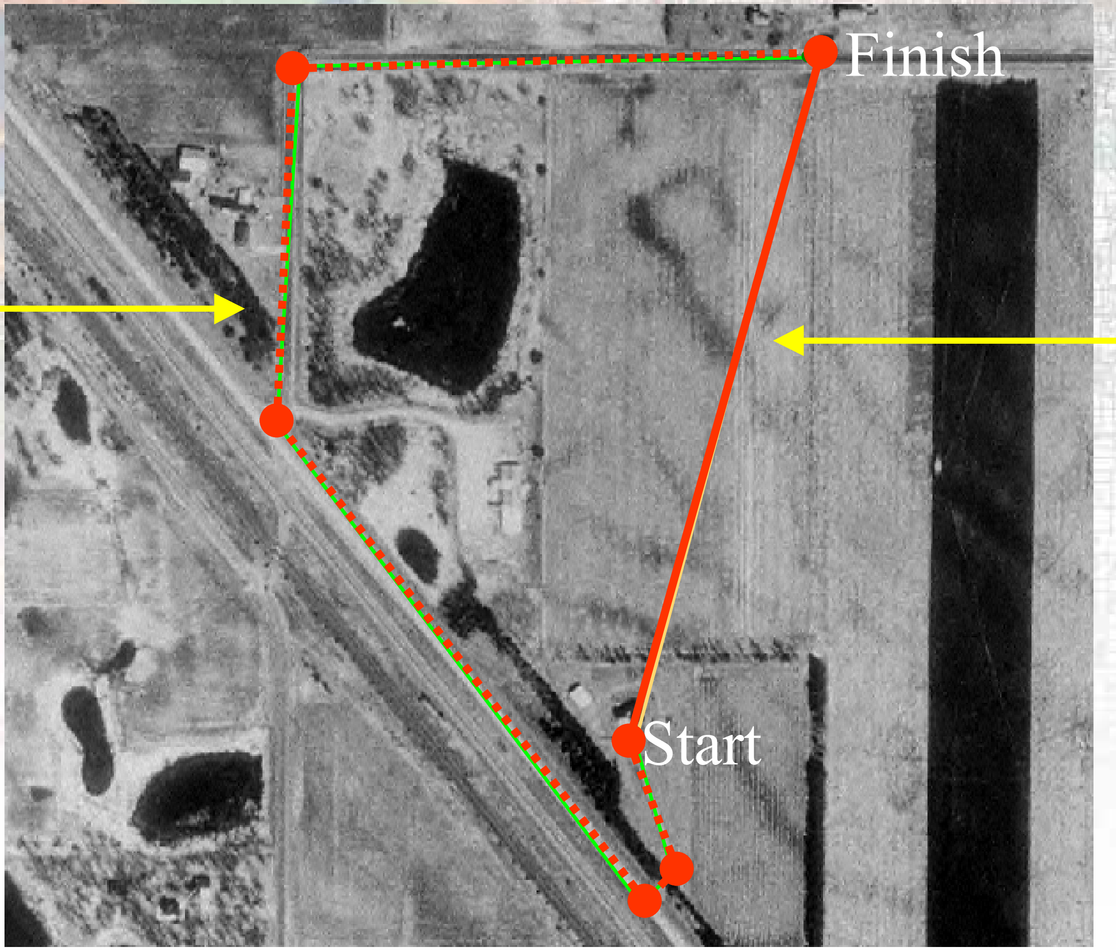
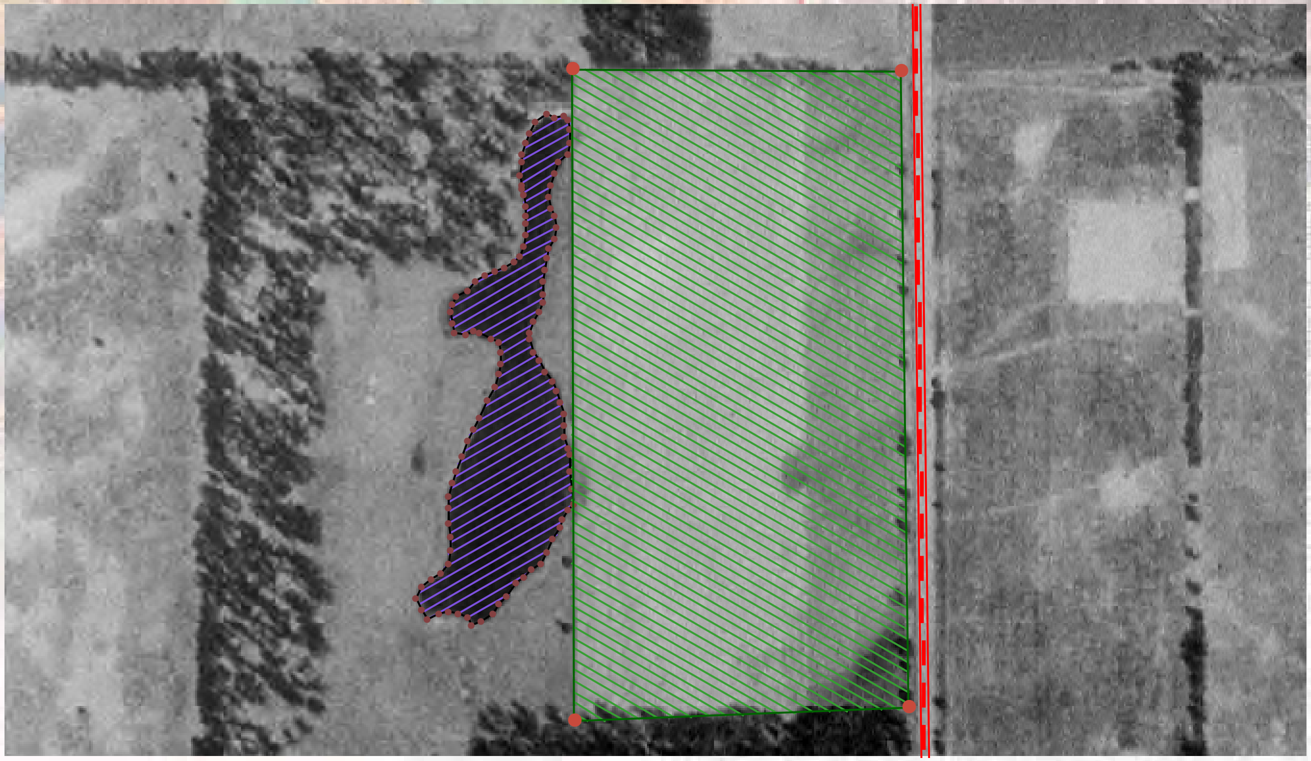
Navigation with GPS

Route between two points



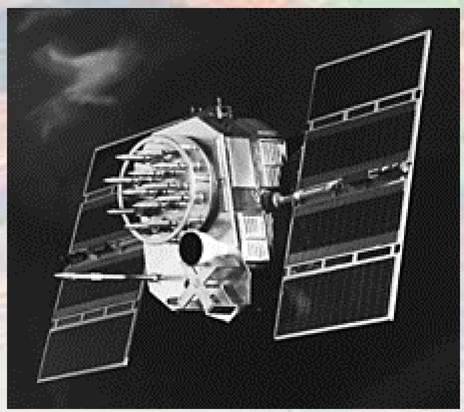
Straight line between two points

GPS Mapping



The data collected using GPS can be used to make maps of natural resources, physical infrastructure or any other geographic features.

Precise time obtained from GPS



The signal that the GPS satellites broadcast contains a very precise time signal that can be read at an accuracy of up to 40 billionths of a second.

Uses of GPS timing:

Financial Markets

Telecommunications

Applications of GPS

Precision Farming

- Use GPS with yield monitors to map the productivity of fields

- Use GPS with variable rate applicators to address variable fertility or weed densities in fields

Digital Photography

- Stamp photographs with the coordinates of the location where they were taken

Navigation

-Use GPS to show your position on a map and guide you to a destination point